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ON THE PINEAL ORGAN OF THE TUNA, *THYNNUS THYNNUS* L.

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A conspicuous pineal spot has been found in many scombrid fishes, e.g. *Thynnus*, *Germo*, *Parathynnus* and *Neothynnus* and the related genera *Auxis*, *Katsuwonus*, *Euthynnus* and *Sarda*. Underlying the pineal spot a fontanelle or "pineal window" (Rivas, 1952) is present in the last four mentioned genera and also in *Scomber* and *Scomberomorus*. Rivas investigated the pineal apparatus of the tuna, *Thynnus thynnus* L. and claimed a photoreceptory role of the pineal area, but he "failed to reveal the presence of a pineal organ, which is apparently absent or greatly reduced" (Rivas, 1952, p. 174). My researches show, however, that a pineal organ is present in the tuna.

A supply of the bluefin tuna, *Thynnus thynnus* L. was obtained from an expedition on board M/S "Delaware," belonging to U.S. Fish and Wildlife Service. Five fishes were dissected, and the pineal organ of each was sectioned and stained, using Bodian's protargol method (Romeis, 1948, p. 421) to determine the presence of nerve elements, and Heidenhain's azan stain (Romeis, 1948, p. 344) for the general histology. The sections were cut at 8 microns, using paraffin technique.

Dissections of the Bouin-preserved material of the tuna revealed, as had previously been pointed out by Kishinuya (1923), Gregory (1933), Godsil and Byera (1944), and Rivas (1952), the presence of a fontanelle, underlying a conspicuous white pineal spot 15 x 30 mm. in size, in a specimen weighing 350 lbs. (Fig. 2). The spot is situated slightly caudally from an assumed

line connecting the centers of the eyes. The dermal layer over the pineal fontanelle was found to be translucent, transmitting about 20 per cent of the light, measured with a photometer.

The fontanelle in the frontal bone, below the dermal layer (Fig. 3), was filled with a jelly-like translucent substance, and measured slightly less than the overlying white pineal spot, about 10 x 30 mm. in the specimen mentioned above.

About 5 mm. below the edge of the frontal bone, the jelly-like material passed into a more cartilaginous type of tissue. A tubular excavation around the pineal organ was formed below the pineal fontanelle, leading down to the brain at an angle of 60 or 70 degrees (Fig. 1). The excavation had a diameter of 10 mm. The end-vesicle of the pineal organ was situated immediately below a dome-shaped cartilage (Figs. 1, 4). The vesicle was approximately 10 mm. in diameter and connected to the diencephalon by a stalk. Ventrally the stalk had a white cord which distally seemed divided into two branches; in the specimen photographed the stalk was 30-35 mm. in length (Fig. 1).

The histological examination of the end-vesicle showed a structure similar to that of most other teleost fishes. The lumen, however, was larger and the walls were thinner, consisting of only one or two layers of cells (Figs. 4, 5). Because the pineal cells were secretory and had cytoplasmic processes extending into the lumen of the vesicle, the cells of the end-vesicle and the stalk (Figs. 4, 5) were similar to the primary sensory cells in teleosts described by N. Holmgren (1920) and Friedrich-Freksa (1932). There were also present supporting cells ("Stützzellen" Friedrich-Freksa, 1932) which had more hyperchromatic nuclei and more indistinct cytoplasm than the sensory cells.

A cross-section of the pineal stalk revealed, especially in the distal part, folded walls. Connective tissue, stained blue with Heidenhain's stain, formed a thin layer inside and outside the wall of the stalk. Silver impregnation did not give any evidence of axons either in the pineal vesicle or in the stalk. A tractus pinealis is present, at least in the proximal portion of the pineal stalk, in many teleost fishes. Apparently the tuna is one of the exceptions.

The pineal structures in the tuna were found to be very vascular, especially below the end-vesicle of the pineal organ (Fig. 4) and in its walls. There, many small blood vessels filled with blood corpuscles were found.

Rivas (1952) suggested positive phototropism in tunas using the experiments of Hsiao (1952) to support his idea. The latter found that both the Pacific yellowfin tuna (*Neothynnus macropterus*) and the Pacific little tunny (*Euthynnus yaito*) showed phototaxis. In these experiments the pineal area was considered to be partly responsible for phototaxis. Breder and Rasquin (1947, 1950) also have shown a correlation in certain teleost fishes between the degree to which the pineal area is exposed to light and the amount of positive phototaxis. Grunewald-Loewenstein (1956) demonstrated in the teleost *Astyanax* that prolonged exposure to light or darkness had an effect on the glycogen content of the pineal. Rasquin (1958) reported that the pineal secretion in teleosts was affected by light; this has also been found to occur in higher animals (Quay, 1956). While there is evidence that light in some way stimulates the pineal's secretory activity, it is also known that the diencephalon in some fishes is light sensitive (Scharrer, 1928; Young, 1935). This had already been indicated by von Frisch (1911) who demonstrated some continuing sensitivity to light by the teleost *Phoxinus* after extirpation of the pineal. Since von Frisch gives us reason to believe that the lining of the ventricle of the diencephalon has light-sensitive cells, and the work of Scharrer and Young corroborate this, the whole pineal area must be included in any discussion on the location of the light-sensitive apparatus. While the histological examination of the tuna's pineal organ showed thin walls which could possibly transmit light, the interior cells did not show any pronounced secretory activity. Therefore, taking into consideration the preceding evidence presented in this paper, one can conclude that while there are morphological indications of the possible light sensitivity of the pineal area in the tuna, there is not yet enough physiological evidence to make a firm commitment as to the possible ecological or hormonal control by this area.

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